Jan. 6, 1970 F. A. ARGUELLES 3,487,618

YARN SPLICING

Filed June 28, 1967 2 Sheets-Sheet 1

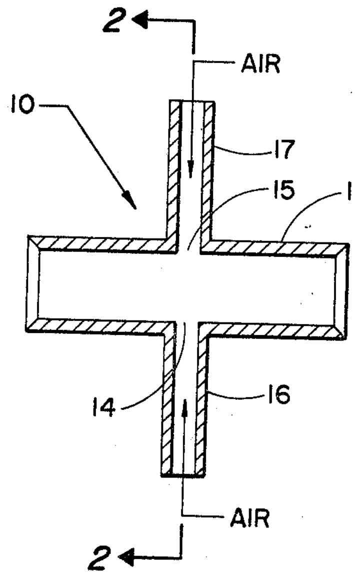

FIGURE 1

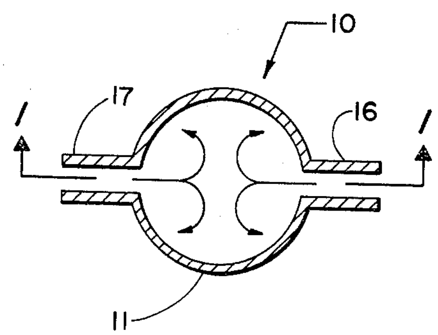

FIGURE 2

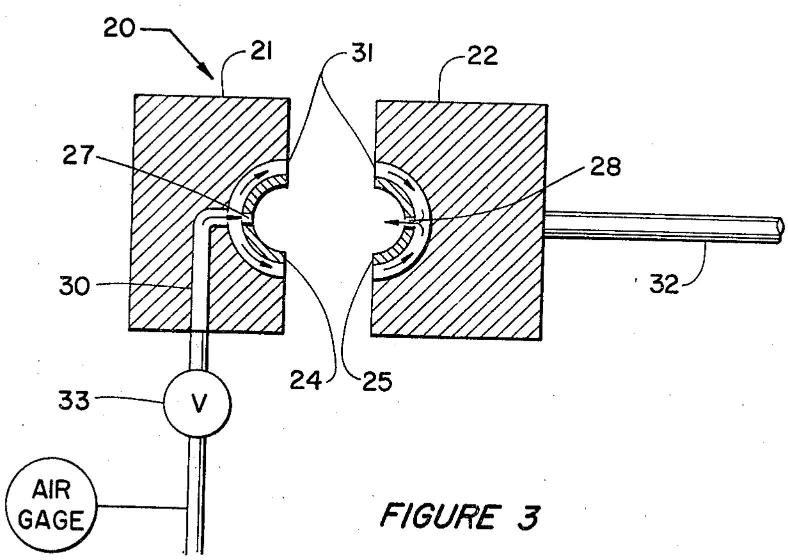

FIGURE 3

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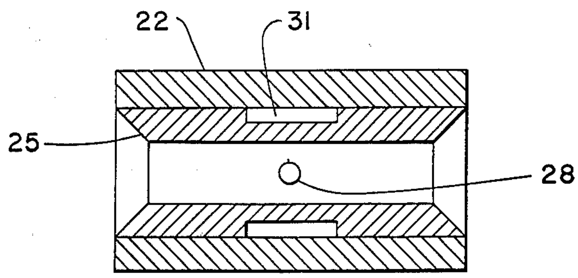

FIGURE 4

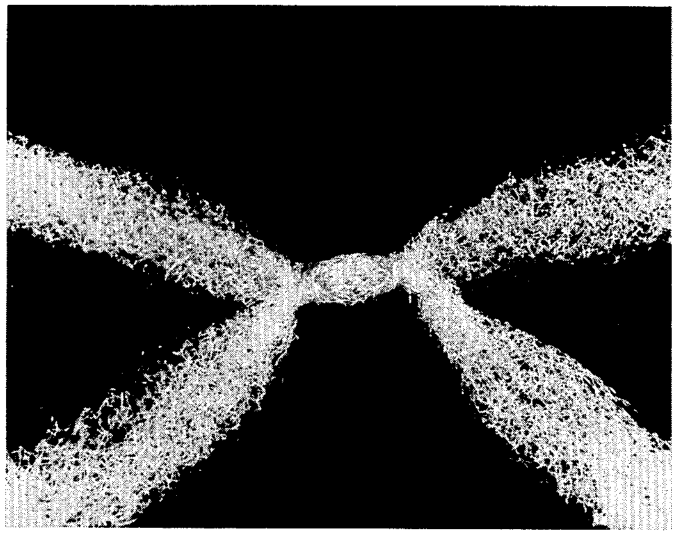

FIGURE 5

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3,487,618
YARN SPLICING

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U.S. Cl. 57—22 **6 Claims**

ABSTRACT OF THE DISCLOSURE

Two yarns are spliced together by subjecting the yarns, located in a confined zone, to the flow of two directly opposed fluid streams.

DEFINITIONS

The expression "yarn" as used herein includes any yarn, strand or structure comprising either continuous filaments singlely or twisted together in the form of yarn, multifilaments, tows, and yarn spun from staple fibers, and the like, any of which are intended for textile uses. The yarns may comprise natural or man-made fibers, e.g. cellulose esters such as cellulose acetate and triacetate, nylon, polyester, and the like, the latter which may be either in a drawn or undrawn state.

By the term "splice" is meant a splice, joint, union, connection or the like, between two or more yarns, which of course includes two or more separate and distinct yarns which may or may not be of the same materials, and a single yarn end doubled back on itself.

BACKGROUND OF THE INVENTION

Field of the invention

The present invention relates to a process for joining, splicing or uniting at least two yarns together and a novel apparatus for performing the process. More particularly it relates to a process of and apparatus for splicing together textured multifilament yarns and to the splice formed thereby.

Description of the prior art

In the textile industry it is common practice to splice or unite yarns together, such being necessitated to repair a break in a threadline or to join pieces of yarn coming from a fresh bobbin onto the end of yarn coming from an exhausted bobbin in order to maintain a continuous supply of yarn for a textile operation. Often it is necessary to rewind packages of yarn into a standard size package, and in doing such, two or more short packages or yarn are united or spliced together in order to make up the one standard size package which goes out to a customer.

Yarns are often joined together or spliced by tying some form of knot therein, or by chemically bonding together or heat splicing together the ends of the yarn. Patent exemplary of such uniting are United States Patent Nos. 1,675,400 (knotting); 1,986,974 (chemical bond); and 3,160,547 (heat sealing). Such splices are, however, attendant with several disadvantages, among which may be loss in tensile strength, less desirable appearance, differential dyeing, and impairment of the continuity of the process. Spliced yarns often result in process stoppages because the splices may be detained by slub catchers, needles in tufting operations, get stuck while being drawn off from a thread package, or the like. Moreover, when crimping a heavy denier yarn, for example in a stuffer box, the yarn is guided into the crimping chamber by means of two rollers and splices may prevent the yarn from passing between the rollers in an unimpeded manner. Further, the tying of knots in yarn and the chemical and thermal splicing thereof often results in yarn that is discolored through handling and moreover, the most desirable chemicals used in splicing often are found to be irritating to the skin of the person preparing the splice.

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It is known also to splice or unite yarns together by a process of air entangling the yarns. Such a process and apparatus therefor are disclosed in United States Patent Nos. 3,273,330; 3,274,764; and 3,306,020; and in British Patent 956,992. While the processes and apparatuses disclosed in the last-mentioned patents offer many advantages over the splicing or uniting of yarn by knotting, chemical or thermal splicing, there are certain disadvantages, however, associated with the practice of such inventions. On the other hand, the inventive concept herein possesses many advantages not heretofore believed obtainable, among which are good utilization of air for the production of splices of relatively high breaking strength, and the provision of such splices at relatively low air pressure. Moreover, and quite advantageously, a process for splicing pre-entangled yarns, as well as yarns of relatively high denier, is provided by the invention herein described.

SUMMARY

In accordance with the invention, hereinafter more fully disclosed, there is provided a simple, economical process of and apparatus having few working parts for splicing at least two yarns together whereby a splice or joint is produced of such a nature that the cross-sectional dimensions thereof does not interfere with the processability of the yarn and provides relatively good tensile strength to prevent breakage at the splice.

The splicing of the yarns together is accomplished according to the invention by positioning the yarns to be united in a generally parallel side-by-side relationship in a tubular-shaped confined zone and subjecting the yarns to the flow of directly opposed turbulent streams of a fluid medium whereby the individual fibers of each of the yarns are initermingled with one another and the yarns are twisted together thereby resulting in a splice of relatively high breaking strength.

Accordingly, the primary object of the invention is to provide a simple process for splicing or uniting yarns together whereby a splice or joint of relatively high breaking strength is produced.

It is a further object to provide a simple and economical apparatus for producing a joint or splice between at least two yarns.

It is also an object to provide a splice in textured yarns which does not impair the texture of the yarn in the final product.

It is still a further object to provide a splice in at least two yarn ends whereby the splice does not impair the continuity of continuous processes in which the yarn is subsequently utilized.

Other objects will become apparent hereinafter when reading the detailed description taken in connection with the drawings wherein;

FIGURE 1 is a cross-sectional view, taken on line **1—1** in FIGURE 2, of a simple apparatus which may be utilized in the practice of the invention;

FIGURE 2 is an end view of the apparatus in FIGURE 1 taken at lines **2—2**;

FIGURE 3 is an end view of a preferred splicing apparatus according to the invention in open position;

FIGURE 4 is a side view of the right housing of the splicing apparatus shown in FIGURE 3, looking toward the shaft; and

FIGURE 5 is an illustration of a splice or joint formed according to the invention between two ends of textured yarn.

DETAILED DESCRIPTION AND DESCRIPTION OF SPECIFIC EMBODIMENTS

Turning now to the drawing there is disclosed in FIGURE 1 thereof, an illustration of a simple splicing device, represented generally by reference numeral **10**, for the practice of the invention. Splicing device **10** has an elongated tubular shaped confined zone **11** in which yarns to be spliced or joined together are postioned. Located equidistant from each end of the confined zone are orifices **14** and **15**, located directly opposite one another, to which are connected in conventional fashion conduits or passageways **16** and **17** for the introduction of a turbulent fluid medium, e.g. air or the like, into confined zone **11**.

While yarns having some twist can be air spliced, e.g. about 2 turns per inch or less, quite unexpectedly it has been discovered that yarns which have been previously textured by crimping and then air entangled can be spliced together in accordance with the invention. This is believed surprising because of the obvious difficulty in further entangling already entangled filaments, particularly in entangling with one another already entangled filaments in different yarn ends. Yarns to be spliced together (not shown) are threaded by means of a wire hook or the like into confined zone **11**. The yarns which are arranged in a generally parallel side-by-side relation with one another may have both their ends facing in the same direction, or the ends thereof may face opposite directions, as desired. Preferably, however, a splice is made between yarn ends wherein the ends of the yarn face opposite directions, or stated in a different manner, where two continuous filament yarns are being spliced, the running lengths of the yarns face in opposite direction. Trimming the tails or loose ends of such a splice results in a more desirable connection which does not have objectionable stubs or protuberances which stick out at any angle about 90 degrees with respect to the running length of the spliced yarns. Moreover, such splice can be desirably trimmed without trimming or cutting the splice per se thus resulting in a splice of higher breaking strength as well as one of more desirable appearance and processability.

The ends of the yarns sticking out from confined zone **11** are held loosely in both hands and are free to move within the zone while air under pressure is allowed to enter orifices **14, 15** simultaneously. The air, which is believed to have the flow path indicated by the arrows in FIGURE 2, causes the yarns to rotate and to twist together between the hands or other clamping means while simultaneously causing individual filaments in each of the yarns to intermingle and entangle with one another. After a few seconds the air flow is turned off and the yarns are removed from the confined zone. The twisting and intermingling of the filaments results in snarls and the like which, along with the friction between the entangled fibers produces a splice between the yarn ends that has relatively good breaking strength, which in some instances is nearly that of the yarns itself.

A more preferred embodiment of a splicing apparatus which is used in the practice of the invention is shown in FIGURE 3 of the drawing. Splicing apparatus **20** is shown in an open position and comprises two housings **21** and **22** which may be abutted together to form a tubular shaped confined zone such as is shown in FIGURE 2 of the drawing, and hereinafter more fully described.

In each of the housings **21** and **22** there is positioned a member **24, 25** forming half of the confined zone. When the members are brought together they form a tubular confined zone for the splicing of yarns as heretofore described. The confined zone so formed is open on the ends and allows for free movement of yarn to be spliced therein. In each of the members **24, 25** there is located equidistant from the ends thereof an orifice **27, 28**, respectively. Passageway **30** in housing **21** is connected with an air compressor (not shown) by means of suitable piping and connections and permits air to flow as indicated by the arrows into plenum **31** and orifice **27**. When the housings are abutted together thereby completing formation of the tubular confined zone air flows via plenum **31** to orifice **28**, and into the tubular-shaped confined zone. Thus yarn within the confined zone is subjected to the flow of two directly opposed turbulent streams of air.

Housings **21** and **22** are the modified jaws of a conventional air vice. Housing **21** is stationary and housing **22** is adapted for movement away from or in engagement with housing **21** by means of shaft or rod **32** which is connected with an air piston (not shown) of conventional design. While the abutting faces of the housings and members **24, 25** are both desirably machined or the like to provide smooth mating surfaces, it is critical that at least the mating surfaces of members **24, 25** be appropriately machined to prevent the egress of air from the confined zone through the mating surfaces. Such is deemed necessary to allow for the proper flow of air in the confined zone which in turn results in the desired splice shown in FIGURE 5 of the drawing. Moreover, in addition to it being critical that the mating surfaces be smooth, it is also of critical significance that such surfaces meet so as to form a tubular-shaped confined zone of uniform dimensions.

Mating surfaces, which do not properly come together at each point along the zone so as to substantially form a circle result in protuberances in the confined zone thus effecting air flow and causing filaments to "hang-up" thereby inhibiting rotation of the yarns. Further to prevent "hang-up" of filaments the inside surfaces of the halves of the confined zone also should desirably be smooth.

As above-mentioned, and the applicant does not wish to be limited by any theory of his invention, the air flows upon being introduced into the confined zone, particularly with the yarns located therein, are believed to follow the flow paths indicated by the arrows in FIGURE 2 of the drawing. Moreover, it is theorized that the air being discharged toward the ends of the confined zone, because of the tubular shape, takes a spiral path, and that such spiral is what influences rotation of the yarns, which results in their being twisted together.

To insure sealing of the mating surfaces, such may be provided with sealing surfaces, e.g. a lamina of rubber or other suitable resilient air-sealing material, if such is desired.

Splicing is accomplished by overlapping the ends of two yarn ends about 8 to 16 times the length of the confined zone (the ends of the yarn can be in opposite directions or in the same direction as desired). The overlapped ends, held in hand, are then positioned in the open splicing device so that when housings **21** and **22** are closed thereby forming the tubular confined zone the two overlapped ends of yarn are positioned solely within the confined zone. It is deemed understood of course that the overlapped yarns can be held in place by appropriate clamping means. It is important, however, in the practice of the invention that none of the filaments in either of the yarn ends are caught during the closing of the housings and that the filaments or yarn ends be freely movable as hereinafter more fully described.

After closing housings **21** and **22** thereby forming the confined zone for the yarn ends, valve **33** is opened thereby allowing air under pressure to flow into the splicing apparatus in the directions indicated by the arrows. Air passes into housing **21** through passage **30** and is introduced into the confined zone by way of orifices **27** and **28**. Upon closing of housings **21** and **22** and turning on air valve **33** air flows up through passageway **30** and divides, some of which flows into the confined zone by way of orifice **27** and the rest of which flows through plenum **30** around the confined zone and into orifice **28** which is located directly opposite orifice **27**.

The yarn ends, while positioned in the confined zone as before-mentioned, are held loosely by means of two hands, clamps or the like. Upon subjecting the overlapped yarn ends to the flow of air, the individual filaments in the yarns are agitated and randomly intermingled and the yarns are twisted together thereby producing a union or splice between the two yarn ends. It is desirable that the yarns be held in the confined zone under little tension. Even more preferably they are held under zero tension thus allowing maximum rotation of the yarns and entangling of the individual filaments.

The size of the confined zone and the fluid passages are dependent to some extent on the yarn that is to be spliced, air pressure, amount of air required for producing a desirable splice, and the like. Such can easily be optimized, however, by means of routine experimentation. Merely by way of example a confined zone one-half inch in length, that is approximately one-eighth inch in diameter, and having fluid passage ways of about one-sixteenth inch in diameter for the introduction of opposed flows of 100 p.s.i.g. air is suitable for producing a splice in a textured yarn having a total denier of 2460/136 or 3690/204.

While the invention is more particularly described hereinafter with respect to air, any type of fluid medium may be employed in the practice of the invention, liquid or gas, e.g. water, carbon dioxide, nitrogen, and saturated or unsaturated steam. For reasons of economy and easiness of handling, the use of air is, however, preferred. The temperature and pressure of the fluid medium used can also be varied, as well as the type of fluid being used. The degree of intermingling and therefore the strength of the splice varies somewhat with pressure and temperature, as well as with the fluid used. The mere selection of a particular fluid entangling medium, and the determination of its optimum pressure, temperature, and the like, for the splicing of any particular yarn according to the invention herein disclosed is deemed, however, within the scope of the routineer. The preferred fluid is air at average conditions of about 100 p.s.i.g. pressure and room temperature. It should suitably be dry, i.e., free of moisture and free from oil, dirt and the like.

The invention will now be more particularly described by reference to the following examples.

Example I

Three running ends of multifilament nylon 66 yarn are joined together in conventional manner to produce a yarn bundle having a total denier of 3690/204. The yarn bundle is then stuffer box crimped after which the filaments thereof are air entangled in conventional fashion to produce a bulky yarn. Two yarn ends of such yarn are overlapped about 6 inches with the ends thereof facing in the opposite direction. The overlapped yarn ends are then spliced by means of a conventional electrically operated heat splicer. The breaking loads on 44 of such splices is given in Table I below.

Example II

Yarn such as is spliced in Example I is spliced using an air splicer having two opposed air flows. The confined zone of the air splicer is cubic in shape being 0.75 inch long, 0.125 inch deep, and 0.125 inch wide.

The yarn ends being overlapped 6 inches and being held by hand at the overlapped ends are subjected to a flow of compressed air at room temperature having a pressure of 150 p.s.i.g. for a period of 5 seconds.

The breaking loads on 20 such splices are given below.

Example III

Yarn as in Example I is spliced by threading two yarn ends into an open-ended confined zone similar to that shown in FIGURE 1 of the drawing.

The confined zone has an internal diameter of 0.125 inch and is 0.500 inch long. It has an external diameter of 0.500 inch and a length of 0.750 inch and flares or diverges outwardly at each end at a 45 degree angle as is shown in the drawing. Two orifices for the introduction of air, having a diameter of 0.062 inch, are located equidistant from the ends of the confined zone and are directly opposite one another.

The yarn ends being overlapped a distance of 6 inches and being held loosely by hand at the overlapped ends are subjected to the opposed turbulent flows of room temperature air having a pressure of 100 p.s.i.g. for a period of 5 seconds.

Upon being subjected to the opposed air flows the overlapped ends of yarn rotate and twist together between the loosely held ends; however, upon stopping the flow of air the yarn ends are unexpectedly discovered to be spliced or connected together along a distance less than the length of the confined zone. Surprisingly, the splice or connection has an intermediate portion which, as can be seen in FIGURE 5 of the drawing, is bulky and obviously less entangled than the ends thereof. At each end of the splice, however, there is a tight spot, i.e. an area of greater entangled than at the intermediate portion. While I do not wish to be held to any theory of my invention the tightly entangled ends of the splice appear to occur at a point along the confined zone which is about half-way from the orifices to the ends of the confined zone. It is theorized that such splicing occurs because the opposed air flows result in a path of flow similar to that shown in FIGURE 2 thereby creating a vortex. The confined zone being tubular shaped is believed to cause the air to spiral toward each end of the confined zone in an effort to escape from the zone which in turn causes the yarns to rotate and twist together thus becoming more highly entangled at the ends of the splice. By the time the air has passed a point beyond about half-way from the orifice to the ends of the confined zone, the air lacks sufficient force to cause any appreciable further entangling.

The breaking load for 20 splices made according to the last-described procedure is given below.

TABLE I

Type of Splicer	Heat Splicer	Example II Air Splicer	Example III Air Splicer
No. of samples	44	20	20
Avg. breaking load (gms.)	893	980	3,330
Max. breaking load (gms.)	1,950	1,105	6,100
Min. breaking load (gms.)	300	935	1,350

As can be seen from the above data there is a significant increase in the average breaking load of the splice made using the air splicer in Example III according to the invention over using the air splicer in Example II or the heat splicer in Example I.

The breaking load, which is above-expressed in grams, is determined by a conventional Instron Universal Tester according to usual techniques. A gage length of 25 cm. and a crosshead speed of 30 cm./min. is used. A 120%/min. strain rate and 12% extension/cm. of chart is used for all testing.

Example IV

Yarn as in Example I is spliced using the preferred device according to the invention and which is shown more clearly in FIGURE 3.

A tubular confined zone such as is described in Example III is split in half according to conventional means (or if desired the semi-cylindrical halves can be machined according to usual techniques from a suitable piece of metal, such as, e.g. stainless steel) to provide smooth mating surfaces within 0.001 inch or less. Such surfaces are required to provide an adequate seal when they are abutted together to inhibit the egress of air through the mating surfaces.

The halves of the confined zone are secured in two brass housings (FIGURE 3) by well-known silver soldering techniques. The housings are part, i.e. the jaws, of a conventional air vise (Heinrich Air Vice No. 33, Heinrich Tools Inc., Racine, Wis.) one of which is stationary and the other movable. The stationary housing contains an air passage 0.188 inch in diameter which is connected with a plenum and orifice in the half of the confined zone located therein. The other end of the air passage is, by means of appropriate connections, connected with an air compressor which provides clean air having a pressure of 100 p.s.i.g. to the air passage. The plenum which is 0.250 inch wide x 0.0545 inch deep (FIGURE 4) and is provided between the housings and the halves of the confined zone allows for the flows of air to the other housing when the housings are moved together to form the tubular shaped confined zone.

The splicing process is performed as follows: two yarn ends are overlapped 6 inches; the ends held by hand, are located within the open splicer; the splicer is closed (see FIGURE 2) and the yarn ends are subjected to the turbulent opposed air flows at a pressure of 100 p.s.i.g. for a period of 5 seconds. The yarn ends rotate as above-mentioned in Example III. The splicer is opened and the spliced yarn is removed. A splice is produced such as is shown in FIGURE 5.

The breaking load on 11 of such splices is given below in Table II.

Example V

In a manner similar to Example IV splices are made on 2460/136 nylon 66 yarn.

The breaking load for a number of such splices is given below in Table II.

TABLE II.—AIR SPLICE BREAKING LOAD DATA

3690/204 Full Load X equals 11,000 gms.		2460/136 Full Load X equals 7,200 gms.	
Gms. Bk. Load	Percent Full Load	Gms. Bk. Load	Percent Full Load
1,300	11.8	1,250	17.3
1,500	13.6	1,400	19.4
1,500	13.6	1,500	20.8
1,650	15.0	1,600	22.2
1,700	15.4	1,700	23.6
2,500	22.7	2,050	28.4
3,000	27.2	2,350	32.6
3,250	29.5	3,000	41.6
3,300	30.0	3,200	44.4
4,300	39.2	3,600	50.0
6,600	60.0	4,000	55.5

Example VI

Undrawn polypropylene yarn (3700/75) was spliced according to the processes described in Examples II and IV.

The splice produced by the Example II process and apparatus broke at between 20% and 50% of the normal yarn tensile strength; however, the splice produced by the preferred apparatus herein, and which is described in Example IV, required over 90% of the normal yarn tensile strength to break.

Although the invention is described above with greater particularity with respect to a modified air vise, it is deemed understood by those skilled in the art that the particular air splicing apparatus may take many forms and still be within the scope of the inventive concept. By way of example, the housings for the confined zone members may be affixed to a die-set for movement toward or away from one another. The housings or confined zone members may be hinged on one side if desired, or both housings can be adapted for movement toward or away from one another. Of critical concern in any apparatus, however, is that the confined zone be circular, and that provisions be made therein for at least two flows of a turbulent fluid medium which are directly opposed one another. More than two splices can be provided, if desired, thereby increasing the strength of the union between two or more yarns. Such can be provided by either building up splicing units as herein disclosed in a

serial fashion or by providing additional pairs of opposed orifices in the confined zone. It may even be desirable in the case of splicing relatively heavy denier yarns or tows to split the filament bundle into two or more subdivisions and thereafter splicing the smaller subdivided bundles of filaments in a staggered manner, if desired, in a number of splicing units arranged in a parallel fashion.

What I claim is:

1. Apparatus for splicing at least two yarns together comprising in combination:

(a) two housing members adapted for movement toward and away from one another,

(b) a first member forming half of a confined zone positioned in one of the housing members,

(c) a second member forming the other half of a confined zone positioned in the other housing member,

(d) means for supplying fluid to at least one of the housing members,

(e) means for moving the housing members toward and away from one another whereby the housing members when moved toward one another cause said first and second members to abut with one another and form a tubular-shaped confined zone open at the ends thereof for the egress of fluid from said zone but being sealed along the abutting surfaces to prevent the egress of fluid,

(f) a fluid passage means located in at least one of the housing members and being interconnected with said fluid supply means and with an orifice located in one of the said members of the confined zone, and

(g) a second fluid passage means being located in the other housing member and being interconnected with an orifice located in the other member of the confined zone positioned therein whereby fluid is supplied to the confined zone in two opposed flows.

2. A process for splicing two or more yarns together which comprises;

(a) individually crimping the yarns to be spliced and intermingling said yarns by air jet entangling,

(b) positioning said yarns in a confined zone in a side-by-side relationship to one another,

(c) subjecting said positioned yarns to the flow of two directly opposed fluid streams, and

(d) rotating said yarns axially along their lengths by means of said opposed fluid flow for a period of time sufficient to cause the fibers of the yarn to become intermingled with one another, thereby resulting in a splice of relatively high breaking strength.

3. Process according to claim **2** wherein the fluid streams are air.

4. Process according to claim **2** wherein the yarns are positioned in the confined zone with overlapping of the ends of the yarns.

5. A process for splicing two or more yarns together, which comprises;

(a) crimping the yarns to be spliced,

(b) positioning said yarns in a confined zone in a side-by-side relationship to one another,

(c) subjecting said positioned yarns to the flow of two directly opposed air streams thereby creating a turbulent zone around said yarns, and

(d) rotating said yarns axially along their lengths in said air stream for a period of time sufficient to cause the yarns to become intermingled and entangled with one another, thereby resulting in a splice of relatively high breaking strength.

6. A process for splicing two or more yarns together comprising positioning two or more continuous filament yarns in a combined zone in a side-by-side relationship to one another, subjecting said positioned yarns to the flow of two directly opposed air streams, thereby creating a turbulent zone about said yarns and rotating said yarns axially along their length in said air stream for a period of time sufficient to cause the yarns to become intermingled and entangled with one another, thereby resulting in a splice of relatively high breaking strength.

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DONALD E. WATKINS, Primary Examiner

U.S. Cl. X.R.

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